Winter-Case - Summer-Case

Building-Envelop-Optimization
to reduce Energy Consumption for Heating, Cooling and Lighting

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SUMMARY

Climate Change is the big challenge for energy-efficient architecture. Buildings have the largest potential of enrgy-saving worldwide.

Already in 1973, as a result of the “oil crisis”, German governments took a lot of efforts to reduce the thermal energy demand of buildings by introducing new regulations. From 1977 to 2002 the admitted maximum heating energy demand of new buildings was reduced from 170 Kwh/m2 a to an average of 80 Kwh/m2 a, which is more than the half. These are the standards for the average mass. Some architects like the author experienced for a longer time to go far beyond the norms and tried even to go to the possible limits.

The building energy regulations were called “thermal insulation regulation “ – WSV until 2001 and were only focused on housing and the winter heating period. In 2002 it had been changed into “Energy saving regulation” – EneV includes although the influence of building technology supply and is measured in primary energy.

In 2007 the new regulation EneV 2006 will although include the energy demand of ventilation, cooling, electricity and lighting.

The new construction rate in Germany is less than 1 % of the building stock. To come to more significant savings the existing and older buildings have to be refurbished for better energy efficiency.

INTRODUCTION

The “Petrol Period” will end worldwide in the middle of the 21st century.
Buildings consume 40 % of the total energy demand.

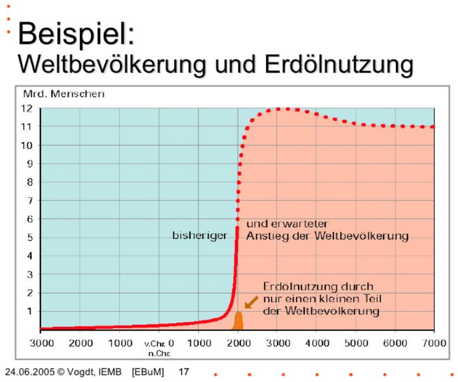

Figure 1: The “Petrol Period, source:IEMB TU Berlin:
World population and oil-consumption in history.

Another important criteria for buildings is the holistic ecological approach “Ecological footprint” (Wackernagel). Every production and consumption of material, every use of energy has an environmental impact on landscape surface. For example: the average german has an ecological footprint of 4 ha. This matters, that Germany produces an ecological footprint with a surface of almost total Europe. If every inhabitant of the world would produce this footprint, humanity would need 4,5 planets. ü 1ü

These two facts make clear, that we as architects and engineers have to develop buildings, that need as less energy as possible.

Development of energy consumption standards in Germany 1977 - 2007

Thermal insulation regulations 1977 - 2002

Germany is imbeaded in climate zones with cold winters and moderate to hot summers.

Housing is consuming the main part of energy use for heating. Air conditioning for housing is not necessary, if these are cimatically well designed. Office buildings need cooling, if they are fully glazed, without solar protection etc.. Anyway it is possible to design office buildings in Germany, which need no artificial cooling or air conditioning, if they are climatically optimized. (See example 2)

The “Oil crisis” in 1973 was a shock to the german population. For the first time this growing economy had to realize, that energy resources could be limited. One of the first reactions was a new governmental “Thermal insulation regulation” – WSV in 1977.

While the heating energy demands in existing building were up to 250 Kwh/m2 a and more, the new regulation reduced the allowed demand in average to 170 Kwh/m2 a.

1984 the next regulation WSV 1984 reduced it to 130 Kwh/m2 a.

The following step appeared in 1995 with a limit of 100 Kwh/m2 a of heating energy demand. ü 2ü

Winter Case:

Example 1: Energy-efficient housing in Vaterstetten, 1994, Arch.: C. Steffan

Figure 2: South façade with terraces and collectors.

The building presented here is a four-storey building which was financed with money of the social housing construction. Altogether, the building accommodates 20 flats, most of them duplex flats on two or three floors. All flats have a terrace of about 14 - 18 m2 which are partly planted.

To minimise the demand of energy of the building the following measures have been realized:

- compact building form,
- high standard of insulation,
- convenient orientation of the building,
- controlled ventilation with heat recovery,
- terminal solar collectors for domestic hot water,
- use of renewable energy and of rain water.

Heating energy demand: 28 KWH/m2 a.

When constructing the building, attention was paid on the prevention of heat bridges. For an optimised use for solar energy, the building has a (nearly) totally glazed south-facing façade with a U-value of 1.1 W/(m2 K). This guarantees that the average of solar gains of the south façade is higher than its transmission losses. The exterior walls consist of 17.5 cm of masonry of sandlime brick which is insulated with 12 cm of mineral wool. By this (conventional) kind of construction the building has a large thermal mass to store solar energy and to decrease summertime temperature peaks. The insulation of the pitch roof consists of 22 cm of cellulose. To minimize the transmission losses to the parking area, the ground has tektalan insulation of 18 cm.

The fully glazed south facade already points to the planned passive use of solar energy. The average value of solar gains through the south-facing facade are larger than the transmission losses of this facade. Fixed horizontal fins for sun protection at the south facade prevent effectively the summertime overheating of the south-orientated rooms.

For the active use of solar energy thermal collectors are fixed on the roof and are integrated into the sun protection fins. Those are used for the heating of the domestic hot water. Altogether, more than 35 m2 of thermal collectors have been installed. This correspond to a little less than 2 m2 collector area per unit of accommodation. Hereby, in summertime about 70 % of the energy demand for domestic hot water can be met.

In every flat an air-heating system is integrated, a combination of fresh air and percirculated air system, which provides this flat with fresh air and heat. (See also "Providing of heat"). The air supply is done in the fresh-air-zones, i.e. in the sleeping and children rooms. The other rooms are provided with percirculated air. Finally, the exhausted air is sucked out in the loaded rooms, which are kitchen, bath and toilet. After that, the exhausted air is sent through a heat exchanger which heats the fresh air. The whole ventilation system can be adjusted very fast, so that solar heat gains can be used better.

The heat for the apartment buildings and also for the other building of the town extension Vaterstetten is provided by the district heat supply. It consists of a chopped wood heating at the rim of the settlement.

By a well insulated network, the heat is transferred from the heating plant to the different buildings and via ventilation system to the flats. . ü 3ü

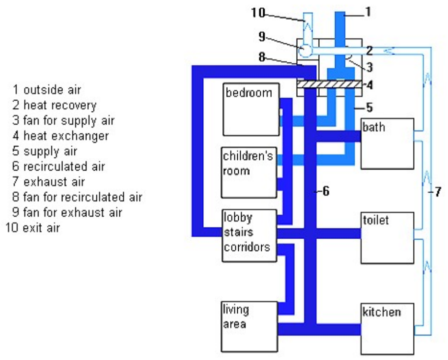

Figure 3: Heat-recovery ventilation system

Energy saving regulations EneV 2002 - 2007

In 2002 a more complex regard was translated in the new “Energy saving regulation” EneV, that integrated energy-efficient building technology to the optimization of the building envelope.

This new regulation had advantages and disadvantages. For example the possibility to be connected to a heating-network can be countervailed by a lower thermal insulation level.

In relationship to the factor heated surface to building envelope surface (A/V) the maximum heating energy demand had been to an average of 80 Kwh/m2 a compared to the WSV 1995.

The new point in the EneV 2002 was the fact, that the energy demand is now expressed in primary energy.

The total production of heating and warmwater is definded with a maximum between 80 and 140 Kwh/m2 a primary energy depending on the A/V factor.

Another new fact of the EneV 2002 was, that exisiting buildings, which are refurbished on a certain ratio, have to proof, that their primary energy demand for heating/warmwater has to be reduced to a defined level.

In 2007 a further going Energy saving regulation EneV 2006 will finally start.

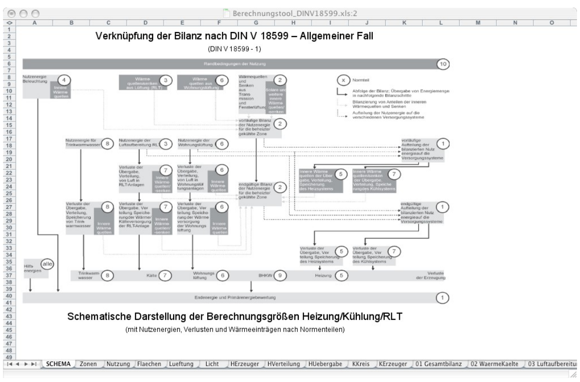

Figure 4: DIN 18599 excel-sheet for non housing buildings

This new EneV will include the other energy consuming factors beside heating energy: ventilation, cooling, electricity and lighting. In a new norm DIN 18599 the maximum primary energy demand of non-housing buildings is defined for the total heating, warmwater, ventilation, cooling, electricity and lighting is precisely defined. ü 4ü

Winter-Case:

The passive-house-standard PHS

The passive-house-standard was developped by the german physicist Dr. Wolfgang Feist in 1991.

Using experiences in Scandinavian countries he calculated, that a much higher thermal insulation standard can reduces the heating energy demand enormously. The thermal insulation of the walls go to 30 cm and more. Glazings in passive houses are triple-glazings with an U-value of 0,8 W/m2 K and less. Thermal bridges have to be avoided.

Another important element of passive houses is the heat-recovery by a mechanical comfort-ventilation-system, which serves as heating-system as well.

The maximum heating energy demand of a passive-house is **15 Kwh/m2 a**. The passive-house-standard since is already realized in several thousand buildings in Germany and other European countries.

The supplementary investment is returning usually within 7 years. Though ist can be considered not only as a good ecological, but although as a good economical solution. The german supermarket chain Aldi Nord is going to build their new markets in the passive-house-standard. The saving in comparison to an average house is more than 90 %. ü 7ü

Example 2: the first german sports and multi-purpose hall in passive-house-standard in Unterschleissheim, Arch.: P S A, A.Pfletscher, C. Steffan

Figure 9: Sports hall in passive-house-standard.

The Sports and Multi-Purpose Hall in Unterschleissheim is an extension of the Rupert-Egenberger-Schule, a mixed-ability school in the District of Munich. The hall is used both for school and club sport as well as for various educational and political events.

The design of the building structure reflects the inner organisation and the external relationships. The building is organised in a modular manner and the individual building sections are combined according to the modular kit principle. The supporting framework, building shell and superstructures are conceived as independent subsystems. Consequently, conversions and modifications of the technical building fittings are possible without a great deal of effort. The modular construction also facilitates the almost complete prefabrication of a large part of the building components.

The application of ecologically compatible, essentially recyclable materials with a long service life and a good ecological balance is an important factor in the planning considerations. The ground floor is built completely in a wooden skeleton style. The roof supporting structure is a glued laminated wooden construction. The spans of the beams are

minimised and the complete construction has been optimised by structural calculations.

The side walls, the roof and the closed parts of the building shell are realised as a two-layered wooden post construction with thermal insulation (40 cm) lying between the individual posts. On the outer side the walls are clad in a rear-ventilated batten cladding of larchwood. On the inner side the walls are lined throughout with pinewood three-layer panels to combine the individual spatial areas to one unit. The surface of the panels is glazed in white to optimise the use of daylight.

The glass facade, a mullion and transom construction with triple thermally insulating panes (U = 0.6) is also a wooden construction and was specially developed for the passive house standard. The fifth facade, the roof, is extensively grassed.

A passive house is a building in which a comfortable interior climate can be maintained without active heating and cooling systems (Adamson 1987 and Feist 1988). The house heats and cools itself, hence "passive". To permit this, the specific annual demand for space heating must be kept lower than 15 kWh/(m2 a), not to be attained at the cost of an increase in use of energy for other purposes (e.g., electricity).

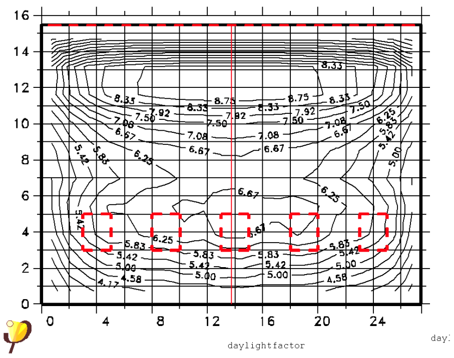

Figure 10: Daylighting diagram.

With this as a starting point, additional energy requirements may be completely covered using renewable energy sources.

Main features of energetic and technical concept:

- Compact form and superinsulation: U-values of all opaque exterior elements 0.15 W/(m2 K) or better.
- Energy-efficient window glazing and frames: Average U-values of windows (glazing and frames, combined) 0.8 W/(m2 K).
- Building envelope: Excellent airtightness.
- Mechanical balanced ventilation system with highly efficient heat recovery from exhaust air: Most of the perceptible heat in the exhaust air is transferred to the incoming fresh air (heat recovery rate over 85%).
- Supply of remaining thermal energy demand: Renewable district heating (geothermic power plant).
- Daylight use and artificial lighting: Window sizing was designed by daylight simulations. During the presence of people a continuous dimming guarantees a minimum use of

electric energy for artificial lighting.

By taking these measures the heat requirement is reduced to such a low level, that a separate conventional heating system in the sports area isn't necessary at all. The future end energy demand for heating of that innovative building will be less than a quarter of the energy consumed by new constructions that complies with the actual national building regulation in Germany. ü 8ü

Summer-Case:

Example 3: Energy-efficient office building in Karlsruhe 1999, Arch.: E. Schneider-Wessling, C. Steffan

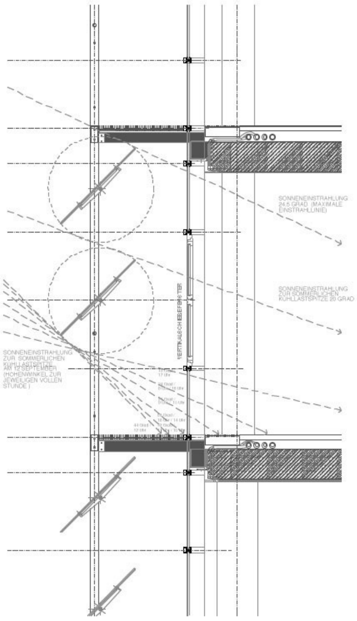

Figure 5: Turning glazed shading devices.

Figure 6: Southern façade with glass louvres

The “House of Economy” of the Chamber of Industry and Trade in Karlsruhe is an efficient low energy-building, even with this high glazing ratio.

The low energy concept consists of the solar winter gains of the southern glazed façade, very high thermal insulation of the roof and the base, triple glazing of the northern façade, a compact volume and optimized shading devices.

A summer night ventilation concept with 3 ventilation-towers in the centers of the building provide a natural cooling up to 6° C during the night. In the next morning the office temperatures are at 20° C and can go up during the day to 26° C. This night ventilation concept is supported by mechanically driven openings in every room, controlled by a bus system to react to storms or fire-incidents. The internal building mass is storing the night cooling to the day period. A supplementary cooling system is installed to cut the temperature on very hot days, which is only necessary during a few days in the year. This cooling is provided by a cooling-ceiling of capillary nets in the plaster of the concrete-ceiling.

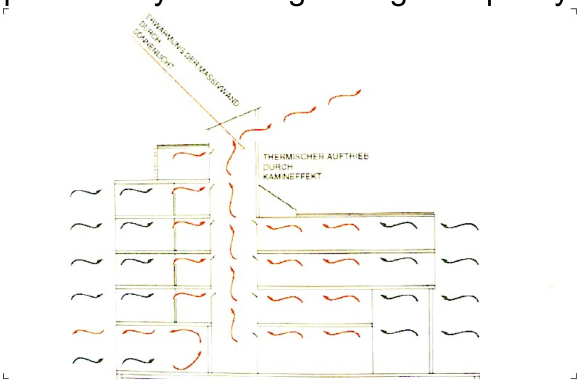

Figure 7: Night ventilation tower.

The southern louvres of reflecting glass, which move with the solar altitude are turned versus the windows on cloudy day to reflect the zenit light to the office ceilings in order to avoid artificial lighting.

The winter heating energy demand is only 40 KWQ/m2 a, the summer cooling energy demand is around 15 Kwh/m2 a. [5]ü 6ü

Summer-Case:

Example 4: Low-Energy High-Rise-Tower MAX in Francfort
Arch.: P S A, A.Pfletscher, C. Steffan with M. Ziller

The High-Rise-Tower MAX in Francfort is designed to optimize the energy-consumption for heating, cooling and lighting and to use environmental energy to get a primary-energy-demand of 100 Kwh/m2 for heating, cooling and lighting.
Triple-glazing, good shading devices in the double-façade reduce cooling and heating energy.
A natural ventilation system of the double-façade and planted wintergardens limit the need of mechanical ventilation. Solar collectors are feeding heat-pumps to get an important part of solar cooling and heating.
Optimized daylighting and energy-efficient lighting systems reduce the energy-demand for daylight-depending dimmed artificial lighting.

Figure 8: Low-Energy High-Rise-Tower in Francfort

Passive Cooling for hot countries
The author is directing 10 Ph.D. – students from mainly asian hot countries to optimize passive cooling systems in their dry-hot and humid-hot home-countries.
Climate- and energy-simulation software is use to optimize building-types. The results are hopeful. The general energy-saving-potential to avoid cooling-energy is enormous.

Winter-Case:

The existing Building Stock

As we have in Germany less than 1 % new constructions per year, the period to change the building stock by new energy-efficient buildings would take to long to get an important impact. From 2007 on every public building has to possess a building-energy-passport, a document, that proofs the primary energy demand of the building. The same is decreed for all new buildings and all existing buildings, which are to be sold or rented. The building-energy-passport has to be elaborated and signed by a qualified architect or engineer.

People on the market will have a transparent overview of the following secondary costs.

The german government is offering now attractive credits to owners, who start energy-efficient building refurbishments.

CONCLUSION

Energy-efficient architecture in Germany is developed far enough to be applied in a large scale and can provide economical benefits. Zero-energy architecture is already realized in prototypes and will be an important part in the future to become more independent ant to reduce the ecological footprint by buildings. ü 9ü

We have to proof that this efficiency can be although realized with high architectural quality.

I am sure that this necessary progress will only come voluntarily. Building regulations for different climate-zones have to be set and be controlled.

For the german architects the energy-efficient refurbishment of existing buildings will be an important part of their commissions.

There will be no other solution. In the future buildings have to demand as less energy input as possible for their construction, use and deconstruction. There are many different solutions specially for different climate zones.

This challenge has to be fulfilled by architects and engineers worldwide in the next years to come.

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